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# Broadening out and opening up technology assessment: Approaches to enhance international development, co-ordination and democratisation<sup>☆</sup>



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## ABSTRACT

Technology assessment (TA) has a strong history of helping to identify priorities and improve environmental sustainability, cost-effectiveness and wider benefits in the technology policies and innovation strategies of nation-states. At international levels, TA has the potential to enhance the roles of science, technology and innovation towards achieving the Millennium Development Goals, effectively implementing the UN Framework on Climate Change and fostering general global transitions to 'green economies'. However, when effectively recommending single ostensibly 'best' technologies or strategies, TA practices can serve unjustifiably to 'close down' debate, failing adequately to address technical uncertainties and social ambiguities, reducing scope for democratic accountability and co-ordination across scales and contexts. This paper investigates ways in which contrasting processes 'broadening out' and 'opening up' TA can enhance both rigour and democratic accountability in technology policy, as well as facilitating social relevance and international cooperation. These methods allow TA to illuminate options, uncertainties and ambiguities and so inform wider political debates about how the contending questions, values and knowledges of different social interests often favour contrasting innovation pathways. In this way TA can foster both technical robustness and social legitimacy in subsequent policy-making. Drawing on three empirical case studies (at local, national and international levels), the paper discusses detailed cases and methods, where recent TA exercises have contributed to this 'broadening out' and 'opening up'. It ends by exploring wider implications and challenges for national and international technology assessment processes that focus on global sustainable development challenges.

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## 1. Introduction

The World Bank recently estimated that 1.5 billion people were living "without sufficient means for human survival" (Chen and Ravallion, 2008; Parsons, 2008). Whilst extreme poverty appears to be falling (United Nations, 2012a,b), gaps dividing rich and poor continue to widen, both between and within many countries (Milanovic, 2010). Global problems of climate change, biodiversity loss and industrial pollution threaten further to accentuate the vulnerabilities and inequalities (Rockström et al., 2009). It is

against this background that widespread international recognition has emerged of the key role that science, technology and innovation can play in helping foster moves to the kinds of 'green economy' discussed at the 2012 Rio + 20 conference (UNEP, 2011; CEC, 2011), effectively implementing the UN Framework Convention on Climate Change (UNFCCC, 2010), maintaining progress towards the Millennium Development Goals (UNDP, 2011) and contributing to a new set of Sustainable Development Goals (United Nations, 2012a,b).

Yet, whilst global annual expenditure on research and development continues to grow beyond one trillion dollars (UNESCO, 2010), economic pressures and co-ordination problems in current systems of governance, mean that only a small proportion of this investment is directly focussed on such global challenges, even when investments are directly and explicitly focussed on development objectives, their wider long-term efficacy is often in question (STEPS Centre, 2010). This is because existing efforts in technology development and wider innovation are typically most strongly steered by powerful incumbent interests, which often do not match

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those of the most vulnerable groups, and frequently fail fully to account for social, technical and ecological complexities and uncertainties.

Technology assessment (TA) offers directly to address these challenges. As defined here, TA is a broad set of practices aimed at informing, shaping and prioritising technology policies and innovation strategies, by deliberately appraising in advance their wider social, environmental, and economic implications. TA has elsewhere been grouped with science and technology foresight and policy evaluation as different tools for strategic intelligence (Kuhlmann, 2001). This paper aims to aid understanding of how TA can address the imperatives discussed above – and explore specific ways in which its performance might be enhanced. To do this, we first describe changing approaches to TA over the past four decades. In particular we outline an approach to characterising TA practices – distinguishing between the ‘broadening out’ of various kinds of inputs to TA; and the extent to which TA outputs ‘open up’ wider policy debate about alternative innovation pathways.

These terms will be returned to in more detail later. But for now, ‘broadening out inputs’ involves extending the scope of a TA exercise in a number of dimensions, such as to include in appraisal a greater variety than might otherwise be considered of problem-definitions, technological options, implementing policies, benefits and impacts, other relevant issues, uncertainties and ambiguities, possibilities and scenarios, values and understandings, as well as methods of analysis and deliberation. The more even the attention to reasonable alternatives in each of these dimensions, the more ‘broadened out’ the particular exercise (Stirling, 2006, 2008). ‘Opening up outputs’, on the other hand, involves not so much the deliberations and analysis that are internal to a given exercise, but the manner in which the eventual findings are communicated externally – not only to clients, but also to associated policy making debates and wider relevant political discourse. In short, this involves the ‘outputs’ of TA being expressed not as single definitive ‘results’, but in a more ‘plural and conditional’ fashion with respect of whatever are the most salient axes of sensitivity that emerge in any of the input dimensions. This in turn means highlighting symmetrically a number of in-principle, equally valid interpretations for appropriate ways forward, each with its associated assumptions, rationales or contexts (Stirling, 2010).

Next, drawing on evidence from three case studies, we analyse how particular aspects of ‘broadening out’ and ‘opening up’ have allowed some TA-style initiatives focussing on international development – either at national or international levels – to overcome some of the general shortcomings in existing patterns of innovation noted above. These findings raise significant practical issues for future TA initiatives, especially as these relate to the harnessing of science and technology for international development.

## 2. Changing debates around technology assessment across the OECD

Technology assessment emerged in the 1960s and was first institutionalised in the United States at the Office of Technology Assessment (OTA) in 1972, and subsequently in several other OECD countries in the 1970s and 1980s (Van Zwanenberg et al., 2009). These institutions arose partly as a consequence of the fierce political controversies around technologies such as civilian nuclear energy. They were seen by proponents as providing an unbiased analysis of the impacts of a technology in order to guide public decisions about which technologies should or should not be supported by the State. Brooks argued, for example, that “*ideally the concept of Technology Assessment is that it should forecast, at least on a probabilistic basis, the full spectrum of possible consequences of technological advance, leaving to the political process the actual*

*choice among the alternative policies in the light of the best available knowledge of their likely consequences*” (Brooks, 1976). Alongside probabilistic forecasting, a variety of quantitative and qualitative methods have been applied, including brainstorming, literature research, document analysis, expert consultation, questionnaires, case studies, cross impact analysis, cost/benefit analysis, trend extrapolation, decision trees, Delphi methods, computer simulations, and scenario development (Dylander, 1980; Tran and Daim, 2008).

Since the outset, arguments were made that TA was not, and crucially never could be, definitively neutral and objective. Critics pointed out that assessments were necessarily dependent on non-technical and often implicit assumptions, especially about the nature of the problems prompting assessment, the questions to be asked, the scope of appraisal, the options under consideration, as well as the appropriate methods to employ and the interpretation of outcomes (Wynne, 1975). These ‘framing’ assumptions were only rarely explicitly acknowledged in TA as contestable value judgements that, both shape – and are reinforced by – its outcomes. In addition, the slow delivery of assessments, the uneven treatment of social consequences, and limited insights into the dynamics of socio-technical systems also received criticism (Sclove, 2010). Although the OTA did respond to accusations of lack of social neutrality by involving particular organised stakeholder groups (academia, industry and civil society groups), it did not develop capacities to elicit knowledges and perspectives of wider publics. Critics argued that the values, outlooks and interests of ‘lay citizens’ were often quite distinct from the understandings and judgements of organised stakeholders.

Technology assessment declined in the United States after the OTA was ‘defunded’ by a Republican Congress under the first Clinton administration in 1995 (Houghton, 1995). However, the concept briefly attracted high level interest again in 2008 when Congress asked the Government Accountability Office to (re-)establish a permanent TA capability. US scholars have recently outlined a number of possible future approaches that could avoid the criticisms of the US OTA (Rodmeyer et al., 2005; Sclove, 2010; Guston and Sarewitz, 2002). Yet, despite the US institutional hiatus of the 1980s–1990s, active international debate around TA has been moving forward elsewhere around the world, delivering a multitude of variant and hybrid methods combining technical analysis with deliberative processes. Each in several tangible ways involves either ‘broadening out’ or ‘opening up’ technology assessment procedures, as compared with other extant practice. Just a few illustrative examples can be mentioned here, to illustrate the general point.

“Constructive TA”, for instance, can extend attention to issues that arise around power dynamics in the research and innovation systems which generate technological particular options rather than others (Rip et al., 1995). Danish-inspired “participatory TA” (pTA) has pioneered involvement of politicians, NGOs, trade unions, journalists, scientists, technology developers and general citizens in appraisal processes, experimenting with dialogue fora, focus groups, and consensus conferences to represent the various views (Klüver et al., 2000). For its part, “interactive TA” was originally developed in the Netherlands to help broaden out appreciation not only of possible response strategies but also of definitions of the problem at issue – as well as attending to issues of iterative learning and effective stakeholder communication within and beyond the process (Loeber, 2004).

Beyond these, there exist a host of variants and hybrids and complements. “Real-time TA” includes elements of all these approaches, with particular consideration to issues of timeliness and efficiency (Guston and Sarewitz, 2002). “Open-source TA” explores a number of ways in which diverse actors can help design and steer such processes (Rejeski, 2005). “Integrative participatory TA” (Hirakawa,

2010) addresses these developments in a particular Japanese context, paying particular attention to the role of technical expertise. “Third generation TA”, again takes elements from several of these and seeks to generalise for wider application (Yoshizawa, 2010). In their own ways, each of these diverse new approaches all aspire to allow inclusive participation of stakeholders in what has been described as agenda-building TA (Kuhlmann, 2001). All these methods, then involve some tangible steps towards ‘broadening out’ and ‘opening up’ in the senses introduced above.

The implications of these developments are truly global. Consensus conferences in the Danish tradition have been taken up by many other OECD countries, including in South Korea, Japan and Taiwan, where public participation in science and technology policy-making is gaining ground (Chen and Wu, 2007). China seems also to be taking more of an interest (Hennen and Ladikas, 2009). There is a resurgence of interest in the US (Sclove, 2010). It is in Europe, however, where development of these contemporary forms of TA has generally proceeded furthest and become most prominent in wider science and technology policy. Interesting progress is being made in several countries towards the institutionalisation of particular approaches, notably in various forms of national ‘Parliamentary Technology Assessment’ (PTA) (Ladikas and Decker, 2004; Ganzevles and Est, 2012). However, divergent cultural (Hoppe and Grin, 1999) and institutional contexts do lead to a degree of distinction between emphases contrastingly on ‘participatory’ methods (pTA) or relations with ‘Parliamentary’ institutions and procedures (PTA).

In the case of participatory (p)TA, both locus and focus of appraisal are unambiguously society at large in all the broader and more open senses discussed above (EUROPTA, 2010). The priority is often placed quite explicitly on catalysing public debate (ADAPTA, 2000) by illuminating relevant divergent societal views (Pellizzoni, 2003), interests and power relations (Ornetzeder and Kastenhofer, 2012). This directly addresses the agendas introduced here around the ‘broadening out’ of inputs to TA and the ‘opening up’ of outputs.

In the case of the more recently consolidating European tradition of Parliamentary (P)TA, on the other hand, the focus is to a greater extent on servicing more specific “clients” (Ganzevles and Est, 2012). Such approaches can show greater affinities with more narrowly instrumental forms of management-oriented TA (Braun, 1998). The entirety of society and political discourse at large can reduce to just one particular “sphere” alongside ‘parliament’, ‘government’ and ‘science and technology’ (Ganzevles and Est, 2012). The priority of PTA, then can lie more in “building connections of trust to the parliament and/or making itself useful for MPs” (Ganzevles and Est, 2012). This is approached by regarding various forms of “policy consultation” (Hennen, 2012) in more institutionally “relational terms” as means to “facilitate mutual discussions” and “the formation of political opinion” (Ganzevles and Est, 2012). Whilst not necessarily inconsistent, these priorities are quite distinct from agendas around ‘broadening out’ and ‘opening up’ the practices of participatory TA.

There exist many exceptions and other sources of contextual diversity at the levels of institutions, organisations and projects (Enzing et al., 2012; Hennen, 2012). These underscore that the salience of ‘broadening out’ or ‘opening up’ can lie in ostensibly obscure and highly specific features of the circumstances or practice of TA. The devil can truly lie in the detail. Despite acknowledging the real progress made in all these traditions, then, there is scope for questioning whether current high profile, newly institutionalising forms of European TA necessarily always display all the claimed properties around broadening out and opening up discussed above (Pellizzoni, 2003; Stirling, 2008; Abels, 2006; Hendriks and Grin, 2006; Bora, 2009; Hoppe, 2010; Ornetzeder and Kastenhofer, 2012; Hennen, 2012).

The purpose of the following discussion is to provide a further examination of the rationale for ‘broadening out’ and ‘opening up’, and to link this especially to the challenges of international development and the contexts seen in developing countries. We then go on to present three case studies that, we argue, have helped move TA further beyond some of the more narrow instrumental forms, involving deep and broadly balanced engagements with public sector, academic and non-government organisations.

### 3. From technology assessment to the social appraisal of pathways to sustainability

While earlier forms of technology assessment focussed on individual technologies in relatively static contexts, current appreciations of physical, social and political dynamics (Scoones et al., 2007) call for a more systemic view. Greater recognition is required of the implications of complexity, uncertainty and divergent values – and of recent understandings of the social (as well as technical) dimensions of innovation (Leach et al., 2007). Seen in this way, TA constitutes one specific set of practices in the wider ‘social appraisal’ of innovation ‘pathways’ (Stirling et al., 2007). Here, the term ‘social appraisal’, refers to the array of social processes through which knowledges are produced and gathered in order to inform decision making and associated institutional commitments (Stirling, 2008). It is in this way, for instance, that societies can better appreciate and explore the plurality of alternative possible ‘pathways to sustainability’ and their associated social and environmental implications (Leach et al., 2010). ‘Broadening out’ the inputs and ‘opening up’ the outputs of social appraisal – both within and beyond TA – can address challenges presented by competing perspectives on innovation-related problems and potential solutions.

### 4. ‘Broadening out’ technology assessment

It has long been recognised (Nelson and Winter, 1982; Rosenberg, 1982; Dosi and Nelson, 1994) that the open path-dependent dynamics of innovation implicate deeper and more intractable forms of uncertainty than it is possible to address in the probabilistic approaches of risk assessment advocated in Brooks’ early characterisation of technology assessment quoted above. An extensive literature has illuminated contrasting states of ‘uncertainty’ – where probabilities are not known (Knight, 1921; Funtowicz and Ravetz, 1990); ‘ambiguity’ – where there is disagreement over defining, ordering or interpreting the possibilities themselves (Stirling, 2003; Jaeger et al., 2001; Dreyer and Renn, 2009) and ‘ignorance’ – where we don’t know what we don’t know (Loasby, 1976; Collingridge, 1983; Wynne, 1992; Stirling, 1998). Each poses more profound challenges for TA than are encompassed in the mere state of ‘risk’ – which assumes both outcomes and probabilities can be definitively measured (Morgan and Henrion, 1990; Stirling, 2010). Yet these crucial lessons are often obscured by the expediently reductive language of risk-based TA, as if all forms of incomplete knowledge remain equally tractable to risk assessment. By more explicitly appreciating the distinctions between these contrasting aspects of incomplete knowledge (Stirling, 1998), roles are revealed for much greater diversities of approaches in TA.

As attention extends to the complex inter-relationships between technologies and the social and environmental systems in which they are embedded, the challenges of uncertainty become more pronounced and the imperatives more pervasive (Stirling and Scoones, 2009). Instead of “pretence” at definitive ‘risk’ calculation (de Finetti, 1974; von Hayek, 1978), inputs to TA can be ‘broadened out’ to enhance the knowledge base



informing decisions (Stirling et al., 2007). This includes extending attention to a greater plurality of interdisciplinary and wider societal knowledges (Renn et al., 1995), and considering a wider array of alternative technological and non-technological innovations (IPTS, 1999; Gee et al., 2002). Including the knowledges of diverse stakeholders and local communities – so often ignored in development-focused TA – can help illuminate, if not reduce, the otherwise intractable challenges of incertitude (Leach et al., 2010).

Where wider relevant knowledges are already available within business, civil society and other stakeholder networks, then, stakeholder engagement offers not only to increase the robustness of TA, but also to reduce the burdens. This is not only because of avoided costs of foregone ill-advised policies, but because open, inclusive deliberation can often short-circuit the need for more expensive protracted efforts at ‘optimising’ analysis using methods (like probabilistic analysis) which are by definition incapable of addressing the intractabilities of uncertainty, ambiguity and ignorance. Instead, an array of practical TA methods offer more rigorously to address different aspects of ‘incertitude’. Under uncertainty, these include sensitivity analysis, interval analysis and decision heuristics (Saltelli et al., 2008). Participatory deliberation, scenario analysis and mapping approaches help address ambiguity (Stirling et al., 2007). For its part, a state of ignorance is in important respects irreducibly indeterminate (Faber and Proops, 1994), as well as socially constructed – and even sometimes increased by further research (Ravetz, 1986). Yet practices do nonetheless exist for TA that can, conditionally, illuminate ways to make technology choices more robust in the face of inevitable surprise (IPTS, 1999; Gee et al., 2002; Stirling, 2012). These include the appraisal of qualities in technological systems like reversibility, diversity, resilience, adaptability and flexibility (Stirling, 2012). All these kinds of appraisals can be obscured and marginalised by the powerful forces for ‘closing down’ of TA using regulatory techniques like risk assessment (Felt et al., 2007).

But the challenge of power asymmetries in social appraisal extend beyond TA methods alone (Wynne, 2002; Jasanoff, 2004; Stirling, 2012). A deeper problem in old models of TA concern the broader imaginations and associated ‘framing assumptions’ that typically underlie institutions as well as analysis. These may shape, for instance, the fundamental aims and visions that are entertained about possible futures as well as the issues and questions that are held to arise about alternative possible innovation pathways. These included the very understandings of what is meant by ‘justification’, ‘benefit’ or ‘harm’ that underlie the organisational remits within which TA is undertaken. Crucially, these social imaginations can also constrict appreciation of the diversities of technological, organisational and wider cultural alternatives that are, often invisibly, associated with any particular proposed course of action. This compounds the tendency for the privileging of technological solutions in TA, as illustrated for example in the field of agricultural biotechnology: by market preferences for innovation trajectories that maximise rent on intellectual property or supply chains (AEBC, 2005) or by the ‘case-by-case’ structuring of typical regulatory processes under which individual favoured products are assessed not comparatively, but in isolation (OECD, 1986).

Here again, those interests which frame the design of TA in wider processes of social appraisal, can (deliberately or inadvertently) predetermine the answers (Mayer and Stirling, 2004). This makes conventional TA practice particularly vulnerable to instrumental (Fiorino, 1989) political pressures for decision justification (Collingridge, 1980) and blame management (Hood, 2002) – often leading TA to be seen more as a tool for legitimisation (Wynne, 1975, 2002) than as a means to greater legitimacy (Pellizzoni, 2001;

Stirling, 2006). It is by broadening out TA, then, that we might resist these perennial instrumental pressures and be more confident that the results achieve a more substantive reflection of shared public values and priorities – including those of less affluent, privileged and powerful groups (NRC, 1996; Stirling, 2008).

## 5. ‘Opening up’ the outputs of technology assessment

So far, discussion has focused on the ‘inputs’ to technology assessment – the uncertainties, issues, perspectives and options that are included in appraisal. Another dimension concerns the outputs of TA to policy processes and wider political debates. Rather than providing a single, ostensibly definitive (objective and comprehensive) characterisation of a technology or technology-related problem (as in old models of TA), an ‘opening up’ approach delivers a more ‘plural and conditional’ set of outputs – each explicitly reflecting not only an alternative reasonable result, but also the associated assumptions, circumstances or perspectives (Stirling, 2008). So, rather than implying a definitively conclusive analysis (simply saying “we recommend undertaking option *A*”), ‘opened up’ TA instead informs decision makers (and wider political audiences) in a more ‘plural and conditional’ fashion. For instance, it may conclude that while some options are unattractive under *any* contexts or perspectives, a different subset of options emerge as equally attractive under particular contexts and perspectives. So, option *B* may be preferable under value judgement *X*, but option *C* under value judgement *Y*. In this ‘opening up’ mode, then, TA acknowledges that subjective differences between *X* and *Y* are matters for political attention – and democratic accountability – rather than technical analysis.

Plural and conditional advice is not a recipe for ‘anything goes’ (Feyerabend, 1978). Crucially, such ‘opening up’ in TA will still highlight those (typically many) options that appear unconditionally *unfavourable*. Indeed, when options are appraised negatively on this more open basis, the grounds for setting them aside may be judged correspondingly more robust (reflecting as they do a plurality of contending conditions, rather than a single privileged perspective). In this way, procedures for ‘opening up’ the outputs of TA reinforce the enhanced robustness due to the broadening out of the inputs, as discussed above. It provides a means at the same time to be more rigorous about the policy implications of key uncertainties and ambiguities – and more accountable and democratic about the particular values that are upheld in decision making (Stirling, 2010).

It is also important to emphasise that orienting TA towards ‘opening up’, is not a recipe for indecisive paralysis. There is no reason why decisions may not still be taken and institutional commitments formed in much the same way as in conventional ‘closing down’ TA. The difference is, that the basis for closure in an opening up approach, becomes more analytically rigorous (through being more explicit and systematic about the effects of alternative reasonable assumptions); and more democratically legitimate (through enhanced transparency and accountability about the implications of – and for – divergent values and interests).

Opening up TA can thus help decision-makers and funders by attending to policy options, issues, uncertainties and perspectives that would otherwise be marginalised. Although not determining a specific decision, ‘plural and conditional’ findings can inform political commitments about which kinds of projects to support or where to allocate resources. And, although not preventing clear political decisions, ‘opening up’ TA can usefully highlight the benefits of diversity (Stirling, 2008). In this way, innovation policy can also gain greater understanding of the ways diversification across a reasonable variety of favoured options may hedge against even the most intractable forms of incertitude discussed above. Diversity in innovation systems also accommodates irreconcilable values

and interests (STEPS Centre, 2010), addresses divergent contexts (Stirling, 2007), mitigates lock-in (Arthur, 1994) and can foster more fruitful further forms of innovation (Grabher and Stark, 1997; Landau et al., 1996). In all these ways, then, the ‘opening up’ of plural and conditional outputs in TA can contribute to more robust decision making in the face of otherwise insoluble policy challenges.

## 6. Technology assessment in developing country contexts

Technology assessment has been much less common in developing countries than in OECD member states. This is despite particularly high profile longstanding recognition that the introduction of technologies into the developing world without adequate or appropriate prior user engagement, assessment or foresight has led to low uptake, wasted investments and counterproductive consequences (Châtel, 1979; Chambers et al., 1989; Goonatilleke, 1994; Scoones and Thompson, 2009). Where it has occurred, TA in developing countries tends to have been largely technical in nature, carried out within centralised institutions or by external consultants in order to direct government or donor projects. Attention to the diverse priorities and understandings of international and domestic stakeholders, and citizens (rural and urban) has rarely been explicit. Relatively recent examples include the application of cost–benefit analysis to the construction of large dams (Mehta and Srinivasan, 1999) and the Vision 2020 exercise, in which the UK’s Department for International Development and the World Bank supported the government of Andhra Pradesh to develop its favoured agriculture and development strategy (including an important technological component associated with modern biotechnologies) (Kuruganti et al., 2008).

The imperative to integrate participatory/deliberative with expert/analytic approaches, now commonly recognised in the USA (Fiorino, 1998; NRC, 1996; RCEP, 1998) and Europe (Renn, 1999; IPTS, 1999; Gee et al., 2002) applies no less in developing country contexts than it does in industrialised countries. Indeed, there is probably an even greater gap between life experiences and priorities of poor users and those of scientific and economic experts in developing country contexts than in industrialised nations (Chambers, 1993). This disjuncture is further exacerbated if TA is conducted by northern donor organisations or experts without the involvement of technology users – or even ‘bridging professionals’, able to relate technical considerations to contexts of use (STEPS Centre, 2010). In addition, the heterogeneity of contexts in some developing countries means that even the same technology can be configured and experienced in very different ways.

The kind of ‘narrowness’ in the social appraisal of innovation described above can be especially problematic in lower income countries. Here – despite strenuous and inspiring efforts – limited governance capacities mean that asymmetries of power, privilege and vulnerability often remain more acute. In particular, problems of destitution compound exclusion of particular communities from markets. Chronic barriers to access to education and political representation can aggravate the marginalisation of interests. These predicaments all strongly amplify the rationale for ‘broadening out’ TA in all the ways discussed here. Although not offering panaceas, many of the methods for ‘broadening out’, mentioned above, can help reinforce wider institutional reforms to help extend the range of alternative options and perspectives engaged as inputs to TA – and so help mitigate the ubiquitously distorting effects of privilege and power. These often harness participatory approaches (Chambers, 1994) to attempt to avoid earlier wasted domestic and external expenditure on technologies for development, by designing more culturally compatible technologies, like participatory plant breeding. However – beyond dispersed and isolated

experiments – mechanisms for meaningfully involving user and wider stakeholders in TA activities have yet to materialise in development settings.

This does not mean that the importance of broadening out the options, perspectives, knowledges and values included in TA is not as recognised in southern settings as it is in the global north. Limited numbers of participatory TA activities associated with emerging technologies and other potential solutions to development challenges have taken place in low income countries. Interest has increased since the 1990s in participatory, ‘deliberative and inclusionary processes’ (DIPs) in areas like the potential role of genetically modified crops in food or fibre production (Wakeford, 2001, 2004). For example, a citizens’ jury on genetically modified organisms (GMOs) in Karnataka, India, delivered a verdict that questioned the effectiveness of Bt cotton in responding to the challenges of poor farmers and raised concerns around environmental sustainability and put forward various alternatives (ActionAid, 2000). Citizens’ juries on agricultural biotechnology have since been facilitated in Mali (IIED, 2007), Zimbabwe (Rusike, 2003), and Brazil (Toni and Von Braun, 2001).

## 7. Technology assessment at international levels

Discussions around international TA for development have a long history, dating back to mandate from the UN General Assembly, in Resolution 34/218, for the Intergovernmental Committee on Science and Technology to:

“initiate arrangements for the early identification and assessment of new scientific and technological developments which may adversely affect the development process as well as those which may have specific and potential importance for that process and for strengthening the scientific and technological capacities of the developing countries” (United Nations, 1979).

However, political and technological realities in the 1970s did not, and could not, allow international participation in such assessments. At more geographically bounded scales (as mentioned above) this proved easier (Enzing et al., 2012). Within the European Union, the STRATA (Strategic Analysis of Specific Political Issues) and STOA (Science and Technology Options Assessment) programmes have attempted to combine efforts across nation states, and work within the OECD has to some extent extended this further through its ‘International Futures Programme’ (which has focussed on global challenges such as future global shocks) (OECD, 2009).

Diversifying sources of innovation, largely outside these established centres (Ely and Scoones, 2009) and the ever-growing pervasiveness of new technologies and their impacts heighten the need for international co-ordination in democratic technology governance. International, networked approaches could also provide important inputs to international research networks collaborating on development challenges and thus building the innovation system linkages and efficacy of what Wagner (2008) terms the ‘New Invisible College’ of scientists collaborating internationally towards shared development aims. These issues again lead us again to identify a vital need for international technology assessment. Despite this need, however, existing policy structures and limits to the accountability of intergovernmental organisations raise continuing questions about the legitimacy and viability of associated TA institutions (Van Zwanenberg et al., 2009). The following section begins to outline examples where these challenges have begun to be addressed by explicit attempts to broaden out and open up technology assessments for development, especially at the international level.

## 8. A case study approach to investigating the opening up of technology assessments

This paper now focuses in detail on three case studies (respectively) in areas of agriculture strategy, emerging technologies for water provision and innovation in crop production. These are: the intergovernmental International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD); a set of NGO initiatives to explore options for potable water provision in Zimbabwe, Peru and Nepal; and a researcher-led appraisal of agricultural innovation pathways in Kenya. Each of these examples was co-ordinated by non-traditional actors (i.e., not national-level technology assessment offices). Each focussed on ‘problems’ rather than individual technologies (as prospective ‘solutions’). And each delivered more open ‘plural and conditional’ outputs to policy. The three case studies have been selected to represent a diversity of: scales (both timeframes and geographical reach); cost (ranging between \$15,000 and \$15 million); participants (variously highlighting private, public, non-government and government sectors); and domains of interest (agriculture and water/health). The methods employed further illuminate important diversities. Given the paucity of data in this area (linked to the relatively small number of TA processes that have taken place in developing countries), a targeted case study of this kind is the only way empirically to gauge the potential – and conditions – for TA to best contribute to equitable international development.

In each case, we evaluate the extent to which the exercise in question can be seen to exemplify the kinds of ‘broadening out’ and ‘opening up’ described above, the mechanisms by which this was achieved, and the associated implications. Of course, the short time lapse (and many complexities) make it difficult to determine the impacts of these real world TA exercises on the actual innovation pathways they examined. An evaluative focus is therefore better directed at the more immediate policy consequences. Here, discussion is based on in-depth analysis of the individual TAs, wider documentary evidence and interviews with actors involved. This methodological pluralism is required to assemble a holistic and robust analysis in each case. But it still encounters several challenges. Documentary evidence (especially policy publications) has particular limitations: even where TA serves to alter policies or technologies, decision-makers may not officially acknowledge this. And absence of counterfactuals raises further significant challenges for conclusions about relative impacts. As a result, an interpretive approach based on multiple data sources offers the best methodological approach.

## 9. Case study details

### 9.1. Case study 1; the International Assessment of Agricultural Knowledge, Science and Technology for Development

The International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) was a joint initiative of the World Bank, UNDP, FAO, and other institutions. Running ran between 2003 and 2008, its aim was “to assess the impacts of past, present and future agricultural knowledge, science and technology on the reduction of hunger and poverty, improvement of rural livelihoods and human health, and equitable, socially, environmentally and economically sustainable development” (IAASTD, 2009, p. vi). The resulting five regional reports and one global report, took four years to produce and cost some \$15 million. It was global in scope and networked – in the sense that it involved multiple institutions in public, civil, and private sectors. This included some

900 people across 110 countries in a multi-stakeholder process involving business, civil society and policy-makers (if not wider citizen participation). The intention was that the results would provide a global consensus for investing in agricultural science and technology, setting priorities for both national and global organisations.

### 9.2. Case study 2; exploring the role of new technologies in clean water provision through stakeholder events in Zimbabwe, Peru and Nepal

“Nanotechnology” is usefully defined in a key British Royal Society report as “the design, characterisation, production and application of structures, devices and systems by controlling shape and size at nanometre scale” (Royal Society, 2004). This includes many new techniques and applications with potentials to drive pervasive changes in society and its interactions with nature. Although put forward by some as a key component of the new ‘green economy’ (Lux Research, 2010), other commentators have pointed to the potential for negative impacts on communities and ecosystems, including in developing countries (Arnall, 2003). The Royal Society report emphasised: “It may also be important to look beyond the perspective of Western industrialised societies, to take account of the ways in which people in developing societies might respond to developments in nanotechnologies and their impacts” (Royal Society, 2004). In a rare example of nanotechnology-focussed TA-type activities in ‘developing’ countries, the international NGO Practical Action joined with other stakeholders to undertake the ‘Nanodialogue’ initiative in Zimbabwe and a range of related activities in Peru and Nepal.

The Zimbabwe event unfolded over three days in 2006, when UK researchers from the think-tank DEMOS and the University of Lancaster, gathered in Harare with Practical Action and local stakeholders, scientists and citizens from two communities in Zimbabwe, to investigate the general challenge of clean water provision (Grimshaw et al., 2007; Stilgoe, 2007; Mellado, 2010).

As part of a larger, UK government-supported programme of ‘Nanodialogues’, the process was organised around the question “can nanotechnologies help achieve the millennium development target of halving the number of people without access to clean water by 2015?” However, the Zimbabwe dialogue focussed on identifying and understanding various sources of problems in water provision, as well as discussing a number of potential technological and non-technological solutions, with nanotechnologies included as just one option among many. By directly involving communities in a participatory process – and addressing not only technological, but also cultural and political issues in discussion – the Zimbabwe Nanodialogue broadened out both technical and nontechnical inputs to the process and also delivered a number of general recommendations to government and non-government actors, nationally and internationally.

The stakeholder workshop approach illustrated by the Zimbabwe Nanodialogue was also used in similar exercises co-ordinated by Practical Action to investigate potable water provision in Peru and Nepal. The emphasis at a seminar (November 2007) and workshop (April 2008) in Peru was on focused on key problems around mercury pollution from small mines in the Andes. These exercises gathered a wide variety of actors together and led to the establishment of a Spanish language website and network across the Andean region and ongoing links with nanotechnology researchers in the UK. Another event in May 2009 in Kathmandu, Nepal, focussed on developing a design brief for an arsenic sensing device for use among contaminated areas of South Asia.



### 9.3. Case study 3: multicriteria mapping of farming innovation in Kenya

Climate change and variability pose new challenges for development. In 2008, a UK Research Council-supported project took maize-based farming strategies in Kenya as a starting point from which to examine different types of innovation proposed by various actors in response to climate change (Brooks et al., 2009). Discussions with farmers, plant breeders, policy-makers, extension workers and executives in commercial seed companies identified nine distinct ‘innovation pathways’. The idea was to open up the debate about alternative responses to environmental change, both within maize agriculture (including high input/low input and public/private options) and out of maize, to other crop-based livelihood options.

A novel aspect of the project was the use of an investigative tool called multicriteria mapping (MCM: Stirling and Mayer, 2001). MCM is a hybrid quantitative–qualitative elicitation tool that can be used in interviews or group settings to appraise an open-ended array of different options and associated issues and uncertainties. In this particular exercise, a broad cross-section of stakeholders were each asked to evaluate nine core ‘innovation pathways’ (options), as well as any others they wished to add. Crucially, MCM prompts participants to characterise their own criteria for evaluating options – and elicits detailed technical ‘scores’ under each.

A further unusual feature of MCM is that it does not just ask interviewees to assign a single score for each option under each criterion. Instead, it elicits two scores: one optimistic, one pessimistic. In each case, care is taken to document the reasoning. As participants iteratively assess all options under all criteria, the software aggregates scores and uncertainties and presents these in easily visualised ways. A specialised analysis tool allows comprehensive exploration of the ambiguities and uncertainties and implications of different perspectives.

## 10. Evidence from the case studies

We now provide a brief review of our case studies, focusing on the extent to which and the ways in which they ‘broadened out’ inputs to technology assessment (in terms of methods, disciplines, perspectives, issues and options) and ‘opened up’ outputs to wider policy debate. We also discuss the challenges and implications of these shifts for the nature of the TA process and subsequent policy decision-making.

### 10.1. How were the inputs to the assessment broadened out?

#### 10.1.1. Broadening participation and options through a multi-stakeholder process – the IAASTD

Right from the outset, the IAASTD was intended to be much more inclusive and participatory, in both design and process, than traditional global expert assessments. A networked, international multi-stakeholder steering committee established the scope – and the processes and procedures by which the exercise would be conducted and governed – following consultation with over 800 participants from diverse sectors and locations (Scoones, 2009). The assessment was overseen by a multi-stakeholder bureau – comprising representatives from government, private sector and civil society. The bureau selected 400 scientists (from a range of disciplines and institutional settings) to author the report. The drafts were subjected to two independent peer reviews by assessors from government, civil society, industry and specialist research institutes. There was no direct representation of farmers or their organisations (either in early consultation stages or subsequently) and limited funds meant it was not always possible for report

authors to consult, as they had been encouraged to do. Some commentators regarded this as a fundamental design flaw, undermining the legitimacy of the effort as a whole. Others saw it as a necessary consequence of convening such an international process, but one which allowed space for (indirect) representation of farmers by NGOs and other civil society organisations.

The inclusion such geographically and sectorally diverse actors had several important consequences. First, it meant that many often-excluded perspectives were voiced – on occasion finding their way into the overall report. As one participant noted: “*perhaps for the first time, those advocating sustainable agriculture and indigenous knowledge had been given a place at the table, and got (some of) their views acknowledged*” (Scoones, 2009). Second, it allowed a range of viewpoints, perspectives, arguments, assumptions and types of evidence to be brought together in one place. This produced frequent tension, especially between traditional production-oriented analyses and perspectives emphasising environmental, social and political issues and the multi-functionality of agriculture. This was considered by some commentators as unhelpful, resulting in an assessment biased against modern biotechnologies (Wager, 2008), but for others it was the result of effective inclusion, where controversies were dealt with and compromise sought (IFOAM, 2008). One of the key findings of the IAASTD is that there are diverse and conflicting interpretations of the past and current role of agricultural science and technology in development, which need to be acknowledged and respected (IAASTD, 2009).

The scope of IAASTD extended well beyond agricultural science and technology with a decision by the steering committee that the assessment should encompass not only scientifically validated studies but also other types of relevant knowledge (e.g., knowledge held by agricultural producers, consumers and end users) and that it should also assess the role of institutions, organisations, governance, markets and trade. One consequence of this multi-dimensional scope of IAASTD, was that the options under consideration became correspondingly more ambitious and wide ranging. Attention stretched to include issues such as: the system of agricultural subsidies in OECD countries; trade rules and intellectual property law; and traditional and local knowledge in community-based innovation. For some, this was too broad: “...if you propose everything, then you don’t prioritise anything” observed one commentator (Coughlan, 2008). Others suggested that the publication of iconoclastic ideas is itself a triumph. An IAASTD spokeswoman argued that “*even changing perceptions of farming is quite a shift from the past 50 years, and they should drive the agenda for the next 50*” (Coughlan, 2008). Either way, this ambition and breadth in the IAASTD managed to stimulate debates in diverse circles, from community groups working on agriculture and development to discussions at the G8 (Scoones, 2008). Debates about issues such as unequal access to food, water and agricultural opportunity have, as a result, been brought further to the foreground of policy debate. The IAASTD has now set a precedent in terms of, for example, inclusiveness, and deliberation over scope, which is reflected in the way future global assessments will now be conducted (e.g., Foresight, 2011).

#### 10.1.2. Broadening participation and options for consideration in the Zimbabwe Nanodialogue

The Zimbabwe stakeholder workshop attempted deliberately and directly to ‘broaden out’ the inputs to the debate. Academics from the Zimbabwean Academy of Sciences, the UK and South African universities were joined by policy makers from several Zimbabwean Ministries and many other public agencies. The process also included members of two different citizen communities, crucially differentiating perspectives, rather than seeing ‘users’ as a uniform group. This enabled attention to be paid to a diversity



of contexts in which nanotechnologies might be employed – with issues such as control and ownership put forward as key issues for consideration in ways that might otherwise have been neglected. It also illustrated some of the problems with previous technology-based solutions, allowing scientists and policy makers to attend to the ways in which nanofilters might fit with the practical challenges faced by poor communities. The community members' responses to previous technologies and the difficulties these raised presented telling insights. For instance, issues emerged around availability of parts or expertise for maintenance and repair, leading to unwelcome dependencies on NGOs. This inclusive approach also allowed cross-interrogation of community and scientific responses to other key challenges, illuminating otherwise-implicit assumptions and highlighting alternative strategies. For example, community members highlighted access issues as the main hindrances to social uptake of new water-related technologies, whilst scientists pointed more to community empowerment and involvement in the development process. Organisers concluded that inclusion of policy-makers and other innovation system actors at the workshop led to greater improved understanding and capacity than would have been the case for a less participatory TA exercise (Gudza, 2010).

The Zimbabwe Nanodialogue was not focused on a technology per se, but around the general challenge of potable water provision (Gudza, 2010). It devoted a whole day towards exploring the broad underlying problems, as seen from diverse perspectives. This broadening out of the range of options considered meant that the exercise was not limited to particular technologies like nanofilters, but also involved wider innovations and practices, including wells, rope and washer/treadle pumps, chemical treatment, boiling water, eco-san, sand abstraction, water divining. Broadening out the inputs to the other Practical Action initiatives in Peru and Nepal also yielded benefits. The Nepal event involved a greater diversity of perspectives and raised a number of issues that would have been overlooked under conventional TA (Grimshaw, 2011a). These included many human aspects associated with the contexts in which the technologies would be used, including data management challenges, capabilities required by local users, cultural issues with the marking of wells, trust amongst different groups and availability of maintenance support. Examination of context-specific technical specifications took user perspectives into account, including preferences for numeric rather than colour-coded displays amongst villagers, required degrees of accuracy and operating temperatures (Grimshaw, 2009). The initiative in Peru informed a later international collaboration to design and test a biosensor for arsenic, again involving expert and lay participants in the development process (Grimshaw, 2011b). This will build further inclusion of local users of the technology, in a region where more than a million people are at risk from arsenic contamination (UNICEF, 2006).

#### 10.1.3. Broadening the mapping of Kenyan agricultural innovation pathways: the MCM method

Multicriteria mapping (MCM) is designed to explore practical policy implications of different stakeholder perspectives. In this Kenyan MCM, a range of potential agricultural innovation pathways were initially defined through discussions with stakeholder groups, who were then invited to assess each on the basis of their own chosen criteria. Alongside the focal issue of enhanced innovation in maize, this illuminated a range of different ways in which different groups: focused on contrasting problems; highlighted contending responses; defined distinct kinds and distributions of benefit and impacts; introduced different uncertainties and – whilst sharing areas of agreement – arrived at disparate conclusions concerning the merits of alternative innovation pathways.

It is unlikely that a top-down, expert led TA would have resolved such a broadly balanced array of options. The ways participants defined and prioritised the impacts of different pathways were also rather different than might be expected from an expert-based process, because they involved more explicit value judgements. As a consequence of this breadth and sensitivity to divergent perspectives, the Kenyan MCM produced a range of interesting, and even counter-intuitive, findings. For example, quite different groups of stakeholders – maize farmers, the biotechnology industry, and public sector researchers – all held in common a relatively optimistic view of alternative dryland crops as a response to climate change, as compared with other options such as commercial, public sector or locally driven improvement of maize varieties.

All the above cases show how a range of tools and approaches can enable broader stakeholder and/or citizen deliberation over key value-laden aspects of TA. Without this, crucial questions might otherwise be neglected, such as: the nature of the focal problems; the choice of appropriate responses; the prioritisation of alternative issues and the relevance of different perspectives. In some cases (e.g., IAASTD) outputs of such deliberations informed more traditional analytical expert-based assessment. In others (e.g., Nanodialogue and MCM) the assessment as a whole was conducted by particular stakeholders and citizen actors.

### 10.2. Opening up the outputs from technology assessment

This section discusses how and to what extent each case study involved an 'opening up' of the outputs of technology assessment – such that a number of viable options were communicated symmetrically to decision-makers. Also discussed, will be the degree to which the different TA methods are conducive to concise, meaningful and efficient communication of 'opened up' outputs to policy debates.

#### 10.2.1. The challenge of opening up outputs in the IAASTD

The IAASTD process struggled to reconcile two commitments. On one hand, was a desire to encourage a plural and inclusive process that genuinely engaged with political and evaluative – as well as technical – issues and which broadened debates around agricultural science and technology. On the other hand, was an expectation that uncertainties could be resolved by a rational, objective, scientific debate among expert peers, leading to common understandings and consensus visions for the future (Scoones, 2009). To some extent, this tension was managed through informal debate and argument rather than allowing different political and value positions to be explicitly acknowledged. The IAASTD did seek to identify where there was consensus and where there was uncertainty, and to discuss minority points of view. Furthermore, it did not make unitary recommendations, only a series of options for action at the global level and each of the regional levels, on the basis that different stakeholders who might wish to act on those options have different sets of priorities and responsibilities, and operate in different socioeconomic and political circumstances.

On particularly contentious issues, such as the potential utility of genetically modified (GM) crops, consensus was unobtainable and recalcitrant differences of opinion led to withdrawal of some private sector participants (Nature, 2008). Such antagonistic dynamics are not necessarily without value. As in wider political mobilisations, such technology controversies can in themselves help catalyse and shape further knowledge production (Felt et al., 2007) and so be thought of as an informal contribution to TA (Rip, 1986). However, the IAASTD did not explore the worldviews and perspectives that underlay this polarisation. As a consequence, the opportunity was not fully seized, to produce a balanced and systematic picture of the particular kinds of reasoning behind the hotly contending positions on GM and its alternatives.

In Johannesburg in April 2008, the IAASTD held an intergovernmental Plenary Meeting to ratify final reports. There was no obligation on governments or others to act on the outputs of the one global and five sub-global reports (Coghlan, 2008). It is thus difficult to ascertain any concrete impacts on funding of agricultural innovation. However, a resulting recognition of the multi-functionality of agriculture has been maintained in subsequent internationally cited UK reports in the same area (e.g., Foresight, 2011) and the director of the IAASTD has claimed that some of the assessment's processes are even being embraced by one of the sponsors (the World Bank) that was previously sceptical to its agenda.

#### 10.2.2. Opening up policy discussions in the Zimbabwe Nanodialogue

Despite being named a 'Nanodialogue', the TA focused on diverse policy responses to water challenges, looking well beyond nanotechnology. Indeed, the shared finding emerged after the first two days that *"there is no real water quality issue that cannot be solved with existing technologies"* is itself an illustration of a kind of opening up that would be impossible under a more singular focus on a particular technology. However, the final outputs of the Nanodialogue were not limited to this consensus. Discussions raised a large number of further questions, including those targeted at scientists about the possibility of using nanotechnologies in combination with other options, as well as the timeframes and specific conditions under which these might be favourable. In this way, this exercise helped frame and put in context any future expert focus more traditionally on nanotechnologies and their conditions of acceptance – illustrating in the process possible organisational synergies between inclusion and expertise and how participation can help frame expert deliberation. The inclusion in the report of unresolved questions, ambiguities and uncertainties, alongside more specific findings and recommendations, also provided an open basis for future societal discussion. This may not have helped bring about direct policy change. Investment was in any case precluded by the context. But the process highlighted the complexities of, and alternatives to, the focal set of new technologies.

#### 10.2.3. Opening up outputs in the Kenyan multicriteria mapping

MCM does not only allow respondents to identify alternative options, choose whatever criteria are wish, freely weigh their importance and express a range of uncertainties – it also directly conveys the implications of this broader scope in the published TA results. MCM therefore emphasises the salient dimensions of diversity across different perspectives, rather than artificially combining these into a single picture, or 'best' option. In principle, then, MCM should help decision-makers better appreciate the range of available choices, we well as different actors' preferences and their associated reasons. As with any specialist method, the utility of this tool relies on training and capacity. However, these upfront investments are quite transferable and – through features like codified procedures and visual representations – themselves help convey the implications of opening up.

In the Kenyan MCM, nine distinct innovation pathways were identified that farmers in semi-arid regions of Kenya might pursue in response to climate change. These ranged from reliance on maize as the key crop to diversification out of maize; and from reliance on internal inputs to external inputs. The pathways were assessed in group interviews, gathering separately men and women and higher and lower income farmers, as well as a range of different kinds of stakeholders. 147 criteria were defined by informants to evaluate the pathways. These ranged from economic issues such as resource costs, market access and availability, through stress tolerance, water use and pest and disease resistance, to wider social, political and cultural issues such as food security and the availability of knowledge and skills. Respondents scored each pathway

using their own definitions of relevant criteria, rating both optimistic and pessimistic scores and ordering criteria in their own sequence of importance.

As an example, Fig. 1 shows the weighted optimistic and pessimistic scores for all the pathways, according to the contrasting criteria and uncertainties expressed by different income and high income subsets of Sakai farmers. The horizontal axis is an ascending scale of performance, with each horizontal bar showing the uncertainty associated with each pathway under each perspective. Among other things, the figure illustrates that both high and low income sub-groups favoured locally improved seed over the dominant option of new maize seed delivered by the public or commercial sectors. But a number of potentially significant contrasts in perspective are also evident (discussed further in Thompson et al., 2011).

As illustrated in the above summaries, there exists a range of techniques than enable the opening up of outputs, ranging from quite specific tools like MCM to simply a commitment to represent diverse views and the extent of consensus and its absence, through an explicit discussion of unresolved uncertainties, conditionalities, unaddressed questions, and finally options for subsequent debate, as in the IAASTD and Nanodialogues exercises. Although there may be issues about reliably representing such diversity, and representing it in a form that is useful for policy-makers and other audiences, perhaps the principal challenge is not with conducting the TA exercises in this way, but with how they are subsequently viewed by decision-makers and other actors. Thus, the problem with the issue of biotechnology in the IAASTD was not the explicit differences of opinion on the role of genetic modification in agricultural development, but the unwillingness of some stakeholders to recognise this as a legitimate and accurate representation of opinion on that issue.

### 11. Lessons for broad and open models of technology assessment for international development challenges

Based on the evidence presented above, what implications arise for new TA institutions – especially those focussing on international development challenges with a global dimension? How can broadened-out and opened up approaches remain useful and enlightening for policy, and what are the challenges involved? This section addresses these questions and ends by discussing their implications for better-co-ordinated and more democratically legitimate international technology assessments.

#### 11.1. Implications and challenges of broadening out

The tendency towards 'broadening out' has been seen in both pTA and – to a more variable extent – PTA in the European Union, has not been studied in developing countries or more broadly. Our cases illustrate a number of advantages of this wider deliberation over value-laden aspects of TA. First and foremost, problem definitions and potential options that are important to user communities were identified that might otherwise have been overlooked in a more traditional TA exercise. Similarly, the IIASTD finding that there are diverse and conflicting interpretations of the role of agricultural science and technology in development that need to be respected is also an important, perhaps underappreciated step towards a more mature, democratic debate about this important topic. More instrumental advantages included the identification of potentially overlooked innovation pathways in the Kenyan maize MCM exercise on which there was nevertheless considerable consensus across stakeholder groups as to their relative merits; and, in the Nanodialogue exercises, the identification of practical

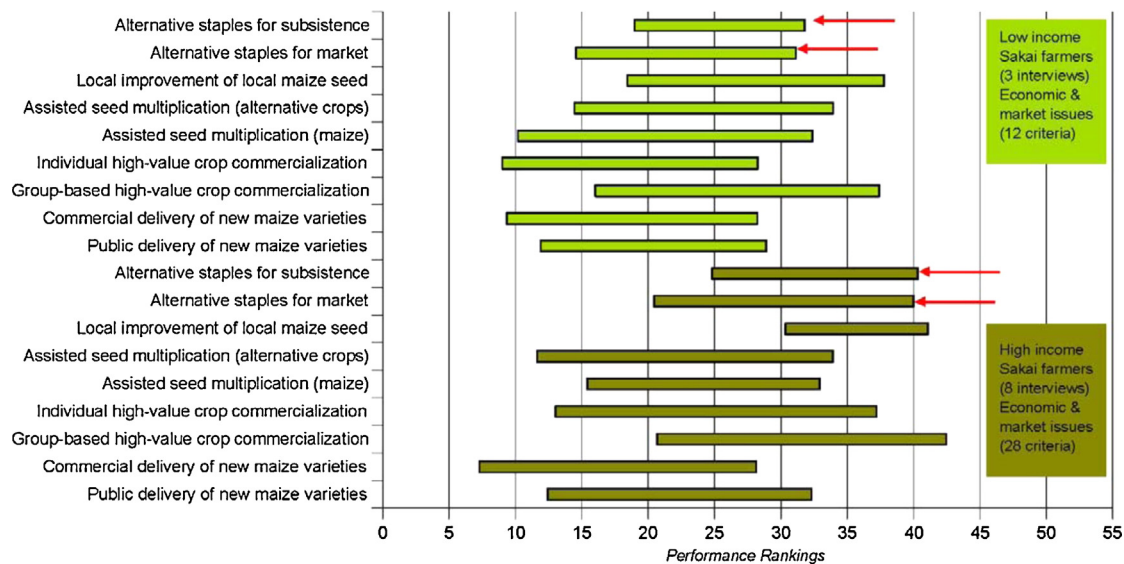


Fig. 1. Performance rankings by low-income and high-income Sakai farmers of the nine pathways against economic and market criteria (Thompson et al., 2011).

problems, such as user capabilities and dependence on outsiders for spare parts and expertise.

Nevertheless, technology assessment continues to encounter a number of challenges as it attempts to ‘broaden out’ the perspectives sought and the options addressed. Firstly, challenges exist for broadening out in the design of TA activities – selecting the stakeholders and representatives to be included in the initial framing of the process. The IAASTD and other trans-national efforts (not directly related to technology) such as the Worldwide Views on Global Warming initiative illustrate how participation of not only stakeholders but also civil society and members of the public has recently been extended to a truly global level, however these successes must be acknowledged to have required significant financial resources and capacity for international engagement and networking across the relevant TA institutions. The case studies also provide similar lessons at the national level. As illustrated by Van Zwanenberg and Arza (2013), technologies can be subject to different configurations (and contribute to different pathways of change), even in different contexts at the national scale. Some of these constituencies are especially marginalised, or may even simply be absent in domestic democratic fora. At the national level and below, the Nanodialogues and MCM cases recognised these challenges by including representatives of urban and rural communities, and farmers of different income levels, respectively. These processes showed that including users and lay inputs was perhaps most instructive at the point of problem-framing. After this, technical expertise was drawn on as required within the context of these broadened considerations and led to further research and development (with continued user input) and other interventions. The fact that these were dependent on external funding rather than being driven by the governments of the countries in which the initial TA activities had taken place is a weakness but also indicative of the complex politics at play in allocating scarce domestic resources to these kinds of initiatives. Experience and appropriate capabilities are sometimes also lacking.

However, challenges extend beyond identifying the breadth of actors to engage at the outset of the TA process, to ensuring that the broad range of participants recognised the utility and validity of the exercise. As noted above, at least some ended up viewing the IAASTD as too broad in scope to be useful. Another challenge was to ensure that participants continued to recognise the validity of the exercise (necessary for their continued participation and

thus the legitimacy of the process). This was especially so where broader kinds of knowledge and perspectives were brought to bear on expert assessments, or where such assessments responded to a more complex set of questions and issues as a result of prior processes of deliberation on issues of scope. Again, in the IAASTD, at least some participants considered the end result overly biased against biotechnology, given the plurality of expert and stakeholder perspectives on the purpose of agriculture (prompting some to exit the process in protest). Such tensions are probably unavoidable (although they may be mitigated by a commitment to opening up the outputs of TA) but the challenge is to diminish their extent and impact without compromising on ambitions to operate in an inclusive, participatory manner.

The case studies also illustrate the practical constraints to broadening out processes of technology assessment itself. IAASTD may have involved a more diverse set of participants than previous efforts, but extending this ‘broadening out’ in an attempt to do justice to the diversity of agro-ecological contexts at play would be impractical and unaffordable (even if employing modern information and communication technologies as proposed by Sclove (2010), Wilson and Casey (2008), and Talyarkhan et al. (2004)). At the same time, coordination of progressively broader processes threatens a bureaucracy that might undermine this diversity with stifling logistical demands. Extending internationally the moves towards more inclusive processes that have been seen in Europe will thus require new institutional innovations. This is especially so if the inclusion of plural inputs and options is to take place in a systematic way that allows cumulative knowledge generation and policy-useful outputs, without over-bureaucratization.

### 11.2. Implications and challenges of opening up TA for international development

The case studies also indicate the benefits, as well as challenges, of opening up the outputs of technology assessment at both the international level and at more local scales.

The IAASTD’s plural outputs recognised the multifunctionality of agriculture and the different values associated with potential outcomes across the globe. It catalysed a shift in debates – most notably providing a key resource for civil society but increasingly being recognised by government and donor organisations. Rather than providing a blueprint for international efforts, it acknowledged

the uncertainties and ambiguities at play and laid bare the controversies that previous multilateral reports often failed to engage with. However, for this, it received significant criticism. The pressure to close down on specific technological solutions (for example by including a chapter devoted to a “Focus on Transgenics”) was evidenced by exit by participants and critique from funders (Nature Biotechnology, 2008). In resisting this pressure, the IAASTD avoided being instrumentalised in the service of one particular technology and instead set the scene for a more open social appraisal of potential innovation pathways (including the social conditions under which they might flourish).

As well as extending participation to include technology users, the second and third case studies are also compatible with methods of ‘opening up’ that seek to deliver more ‘plural and conditional’ outputs – relating conclusions to assumptions (and especially questioning expert assumptions regarding the suitability of certain options). One challenge is presenting this kind of output in an easily accessible and clear format. The MCM exercise in particular enables communication of these outputs in an efficient way. Whilst the accessibility of these outputs to policy makers requires further investigation, this tool does present a scalable approach to eliciting and comparing perspectives in international, networked forms of TA.

Another challenge (potentially levelled at all three cases) might have been said to have been the absence of a clear policy solution. Whilst this might have been seen as a weakness of these particular cases, they in fact recognised the opportunities, as well as the difficulties and constraints associated with each and every option appraised, providing a full and robust input to subsequent policy-making, which can itself be seen as a strength. ‘Closing down’ to a circumscribed set of options is not the role of TA. Instead, such commitments are the domain of politically accountable decision-makers, and if TA is to contribute to the democratisation of technology governance, rather than succumb to instrumentalisation by powerful groups, its role should be to resist processes of ‘closing down’.

Thus, rather than necessarily delivering definitive policy advice, broad and open approaches to TA also enable the inclusion of actors directly engaged in knowledge production or development of new technologies and practices, offering a means to ‘wire up’ an innovation system, as Martin and Johnston argue with respect to technology foresight (1999). This strengthens connections between actors and institutions involved in innovation processes (e.g., private firms, public sector research centres, users, funders, decision-makers) allowing knowledges to flow more freely between diverse actors, and learning to pervades more readily across social barriers.

Networked approaches (for example those convened by Practical Action) delivered diverse but inter-articulating outputs (both in terms of needs and resources) in different parts of the world. There are significant challenges in linking up these relatively isolated initiatives across institutions to provide plural, but at the same time coherent and cumulative bodies of knowledge. In this case co-ordination is required to ensure that various technology assessment processes at once ‘speak to each other’ but are flexible to the diversity of contexts in which they are positioned. Whilst challenging, this could enable opportunities to link strategic intelligence from a wider range of previously isolated locations or contexts. In addition, this form of ‘openness’ would raise the potential for TA to document diversity in worldwide innovation pathways in given sectors – in ways that recognise the benefits and trade-offs associated with standardisation and diversity (Stirling, 2007). At the same time, however, as discussed above, institutional innovations and more responsive and plural governance are necessary for these kinds of approaches to take hold at national or international levels.

## 12. Conclusion: broadening out and opening up national and international TA for sustainable development challenges

Across the world, TA is at a crossroads. The interconnectedness of different nations and innovation systems, the shared nature of global problems and the pace of innovation demands diverse and coherent forms of communication and action. Urgent high profile calls are made for global momentum towards more sustainable innovation pathways – that are more robust in relation to societal needs and values and legitimate and accountable in their orientation and implications. It has been argued above that TA practises of various kinds have crucial roles to play in fostering more democratic appraisal of innovation to serve these goals. In this context, a number of the lessons emerging from the present analysis may hold value for design and implementation of more broadened out and opened up TA.

There is a need to move beyond a series of unconnected, isolated TA experiments, towards more coherently co-ordinated (but still diverse) internationally networked approaches as illustrated (notwithstanding its limitations) by the IAASTD. In allowing participatory TA to be scaled up in wider areas of the world, the focus should not just be on specific TA exercises in particular settings, but also on broader cross-national programmes – enabling cumulative distributed learning about contending innovation imperatives and possibilities. TA at international levels should focus on maintaining and enriching the diversity of social and technological approaches to addressing particular challenges – as seen from plural perspectives. A particular role for globally networked TA, is to enhance visibility and scrutiny of increasingly intensive pressures for international harmonisation and standardisation.

There are obvious areas where resources and capabilities for broader and more open forms of TA are currently especially lacking. For instance, there is an urgent need for network support and methodological capacity-building for TA in many developing countries. The case studies in this paper refer to some extent to external groups entering developing countries and co-ordinating technology assessment activities. If developing country citizens and stakeholders are to speak for themselves, they need to be empowered not only to conduct, but also co-ordinate rigorous and systematic assessments, drawing on and adapting the kinds of tools discussed in this paper to suit local contexts and imperatives.

Resources, capacity and governance arrangements may often also be lacking or inappropriate for effective debate and decision making in response to Open TA. Acknowledgement of these realities forms an integral part of the quality of openness, not least to avoid disillusionment – and disrespect of participants. Nevertheless, the ‘broadening out’ and ‘opening up’ of TA described here may generate tacit learning within wider innovation systems, even if particular outputs do not become the explicit basis for concrete ‘decisions’. In addition, it can catalyse a more transparent and democratic debate around pathways to sustainability and development.

Arguably the most crucial systemic requirements for more broad and open TA are the same qualities towards which it arguably contributes: a strengthening of responsive relations in the governance of innovation – between business, academia, government and civil society. Under these conditions, the characteristics of TA processes analysed and advocated here, offer ways to help enhance both technical robustness, societal relevance and democratic accountability in global innovation systems. Whilst they may present institutional and political challenges that are not experienced in narrower (more technocratic and instrumental) forms of TA, this is a necessary consequence of doing justice to the magnitude of the current global imperatives and potentialities for innovation with which this paper began.



In conclusion 'broadening out' and 'opening up' technology assessment enhances appreciations of the inherently social and political implications, uncertainties and possibilities of innovation. The cases here illustrate that these characteristics – already recognised to varying extents in European debates – have a vital role to play in international development processes at different levels. Internationally networked and co-ordinated TA with these characteristics can enable the vital energies and outputs of worldwide innovation systems to become more socially equitable, environmentally sustainable and democratically legitimate.

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